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MILITARY HANDBOOK

WIRE COMMUNICATIONS AND SIGNAL SYSTEMS

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ABSTRACT

Basic design guidance, developed from extensive reevaluation of facilities, is presented for use by experienced architects and engineers. The contents cover guidelines for various types of wire communication and signal systems, including telephone and telecommunications, hospital nurse call, doctor paging, doctor registration, intercommunicating, sound, cable, fiber optics, television, television master antenna, frequency modulated master antenna, closed circuit television, clock and programming, watchman tour, disaster alarm, central dictation, and remote control and monitoring. It does not include fire alarms or other hazard alarm systems.

FOREWORD

This handbook is one of a series that has been developed from an evaluation of facilities in the shore establishment, from surveys of the availability of new materials and construction methods, and from selection of the best design practices of the Naval Facilities Engineering Command, other Government agencies, and the private sector. This handbook uses, to the maximum extent feasible, national professional society, association, and institute standards in accordance with NAVFACENGCOM policy. Deviations from these criteria should not be made without prior approval of NAVFACENGCOM Headquarters Code 04.

Design cannot remain static any more than can the functions it serves or the technologies it uses. Accordingly, recommendations for improvement are encouraged and should be furnished on the DD Form 1426 provided inside the back cover to Commanding Officer, Naval Facilities Engineering Command, Code 04, Chesapeake Division, Washington Navy Yard, Washington, D.C. 20374-2121; phone (202) 433-3314.

DO NOT USE THIS HANDBOOK AS A REFERENCE DOCUMENT FOR PROCUREMENT OF FACILITIES CONSTRUCTION. IT IS TO BE USED IN THE PURCHASE OF FACILITIES ENGINEERING STUDIES AND DESIGNS (PLANS, SPECIFICATIONS, AND COST ESTIMATES). DO NOT REFERENCE IT IN MILITARY OR FEDERAL SPECIFICATIONS OR OTHER PROCUREMENT DOCUMENTS.

ELECTRICAL ENGINEERING CRITERIA MANUALS

Number	Title	PA
MIL-HDBK-1004/l	Preliminary Design Considerations	CHESDIV
MIL-HDBK-1004/2	Power Distribution Systems	PACDIV
MIL-HDBK-1004/3	Switchgear and Relaying	CHESDIV
MIL-HDBK-1004/4	Electrical Utilization Systems	CHESDIV
DM-04.05	400-Hertz Generation and Distribution Systems	SOUTHDIV
MIL-HDBK-1004/6	Lightning Protection	CHESDIV
MIL-HDBK-1004/7	Wire Communication and Signal Systems	CHESDIV
DM-04.09***	Energy Monitoring and Control Systems	ARMY
MIL-HDBK-1004/10	Cathodic Protection	NCEL

***Tri-Service Manual

WIRE COMMUNICATIONS AND SIGNAL SYSTEMS

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Section 1: INTRODUCTION

1.1 Scope. This handbook presents guidelines for selection and application of wire communication and signal systems. These include telephone and telecommunications, nurse call, doctor paging and registration, intercommunicating, sound, cable television, master antenna, closed-circuit television, clock and programming, watchman tour, disaster alarm, central dictation, and remote control and monitoring systems.

1.2 Cancellation. This handbook, MIL-HDBK-1004/7, cancels and supersedes DM-04.07, dated April 1986.

1.3 Policy. Follow standards set by National Fire Protection Association (NFPA) 70, National Electric Code (NEC), and American National Standards Institute, Inc., (ANSI) C2-81, National Electric Safety Code, throughout all designs. Designs for materials and equipment shall conform to the standards of the National Electrical Manufacturers Association (NEMA), Underwriters' Laboratories, Inc. (UL), and other professional organizations.

1.4 Specific Criteria. System requirements are determined by the specific criteria for that facility. See the appropriate criteria manual. Also consider the requirements of the using agency. Where more than one system is necessary, it might be more economical to combine several functions. Examples of these are combining the central dictation system in the telephone and tele-communication system, or the nurse call, radio, and television systems into one system. It is especially important that systems for health care facilities be coordinated with each other, and with the requirements for essential electrical systems, so that life safety and support systems are efficient and functional. Consideration should be given to incorporating program and other central systems, as a part of the energy monitoring and control system (EMCS), to prevent duplication of facilities.

Section 2: TELEPHONE AND TELECOMMUNICATION SYSTEMS

2.1 Description. These systems connect telephones and data terminals on a naval activity with any other telephone data terminal connected to the system. A system consists of a switching device, a wire distribution system, and various types of station equipment. The system usually provides the capability for stations at the activity to place calls to and receive calls from telephones or data terminals located outside the activity.

2.2 Design Responsibilities. Areas for design of a new or expanded telecommunication system are outlined in the following paragraphs.

2.2.1 Type of Solicitation Documents. If a base administrative telephone services contract is desired, stipulate that one vendor be responsible for providing all telecommunications services on the base and coordinate with off-base communications providers as required. Define the type and parameters for the level of service desired. If a purchase acquisition document is desired, state the number and technical specifications for each type of equipment required for the system.

2.2.2 Glossary. Provide a glossary to include a precise definition of only those terms used in the procurement documents.

2.2.3 DSN/AUTOVON/FTS Compatibility. If an activity has or will have access to the Automatic Voice Network (AUTOVON), the Defense Switched Network (DSN), or the Federal Telecommunications System (FTS) provide for compatibility with their signalling systems. (See Defense Communication Agency (DCA) Circular 310-V-175-6, System Interface Criteria, and DCA Circular 310-225-1, DSN Phase 1 User Services Guide, for AUTOVON interface requirements. See also DCEC R610-001, Defense Switch Network, Generic Switching Center Requirements, published by DCA for DSN specifications.)

2.2.4 Voice and Data Considerations. Be aware that, historically, the usage of voice communication has increased in the past and will probably continue to increase in the future, but at a lower rate as more data transmissions are made. The requirement for data switching and transmission has increased dramatically in the recent past, and will continue to increase at a very rapid rate in the future. Dialed-up data transmissions are usually characterized by lengthy calls.

2.2.5 Overseas. Most off-base communications facilities in foreign countries are provided by Government-owned administrations. They frequently do not use the same signalling systems and transmission levels found in the continental United States and Canada. Provide the required converters and interfaces.

2.2.6 Expansion. If it has been determined that an existing system should be upgraded or expanded to meet current and forecasted demand, take action as follows:

2.2.6.1 Leased System. Direct the lessor to furnish the necessary equipment, compatible with the existing system, to provide the service required.

2.2.6.2 Owned System. Analyze the existing system circuitry and specify compatible equipment to provide the service required. Follow the instructions contained in this section to the extent practicable.

2.3 Existing Service. Provide statistics on the number and type of instruments, type and capacity of the switching machine, and number and type of trunks by trunk groups currently in service.

2.4 Forecasting Future Requirements - 10 Year. From all available sources, such as historical trends, plans and programs, and personal interviews, develop a fundamental plan. This plan should be by building, by cable route, and by system for a minimum period of 10 years.

2.5 Traffic Studies. If current traffic study data are available, provide a summary to be used in developing system capacity and design. If current studies are not available, make appropriate studies during the busiest hour of the day for 5 consecutive business days. Conduct these studies, preferably, during the busy season. If this is not possible, make appropriate adjustments or use the following figures until more accurate data can be acquired:

a) Busy hour call attempts: 3.0 per station.

b) Voice traffic: 6.0 hundred call seconds (CCS)/hour total per each subscriber line/port.

c) Data traffic only: approaching 36 CCS/hour per data terminal.

d) Facsimile traffic only: 12 CCS/hour per facsimile terminal.

2.6 Single-Line Stations. A study should be made of the existing service. Be aware of the Navy's program to provide a dedicated telephone (and telephone number) to each user to the maximum extent possible in all new digital switching telephone systems.

2.7 Switching Equipment Design. Specify that new switching equipment be digital. If the procurement is for a base administrative telephone service contract, the vendor will provide the design that best meets the service requirements. If the procurement is for purchase, require that the system design be any appropriate combination of space-time division, but must use a form of pulse code modulation compatible with a direct interface with T1 carrier systems. It shall be modular in design for economical expansion, it may use distributed or central processing, and must provide redundancy of critical components.

2.7.1 Numbering Plan. Provide details about the station numbering plan, access codes, and service codes. If a new numbering plan is required, it will be necessary to negotiate with the local telephone company for an acceptable numbering plan suitable for direct inward dialing.

2.7.2 End Office Versus Tandem. Determine if the new switching equipment will function as an end office, or as a combined end office and tandem office in the network hierarchy. Define the requirements accordingly.

2.7.3 Precedence. If the new equipment will have access to AUTOVON or DSN, provide for handling precedence traffic.

2.7.4 Data Transmission. Require the new switching equipment to have the capability of switching data stream traffic of at least 19.2 kilo bits per second. Depending on the system design, it is desirable, but not mandatory, that the data lines be served by a separate switch node with a grade of service of P.000001 and bit error rate not to exceed 1 in 10,000,000.

2.7.5 Push Button Dialing. The equipment must be capable of accepting push button dialing, using dual tone multifrequency tones, in accordance with Rural Electrification Administration (REA) Bulletin 345-74. It shall also accept pulses from rotary dials adjusted to industry standards.

2.7.6 Tones - Frequency. Provide the frequencies and levels (voltage) for the following tones:

a) Dial.

b) Station busy.

c) Congestion (all trunks busy).

d) Ringing - external versus internal calling.

2.7.7 Grade of Service. Provide for a grade of service (GOS) as follows:

a) Switching (voice): P.005.

b) Switching (data): P.000001.

c) Trunks except AUTOVON: P.01.

d) AUTOVON (2 way): P.05.

e) AUTOVON (1 way in): P.05.

f) Dial tone delay (station): 1.5 percent over three seconds maximum.

g) Dial tone delay (console): 1.5 percent over one second maximum

2.7.8 Station Loop Limit. This shall not exceed 1500 ohms DC resistance, from the switching equipment to and including the station equipment, for analog equipment. Range extenders, or range extenders with gain must be provided for station loops that exceed this resistance. Transmission loss shall not exceed 8 decibels measured at 1004 hertz. The maximum resistance between a data terminal and a digital switching machine is about 200 ohms of paired conductors.

2.7.9 Station Features. Modern digital switching equipment can provide a large number of features that are station selectable. Some are included in the basic system; others require extra memory or hardware and are available as options at additional cost. A station-by-station analysis to determine those features which will be cost effective for each location should be made.

Following is a list of features that should be considered:

a) Abbreviated dialing.

b) Automatic call back.

c) Call forwarding (transfer).

d) Call pickup.

e) Call waiting.

f) Hold.

g) Three-way conference.

h) Hunting

i) Restriction (class of service).

j) Call coverage (transfer to message center).

k) Message waiting indicators.

l) Restricted route selection.

m) Trunk queuing (on-or-off hook).

n) Executive right-of-way.

2.7.10 Data Features. For dialed up data transmission, select the appropriate features from the following:

a) Simultaneous voice and data.

b) Data only.

c) EIA compatible.

d) Modem pooling.

e) Queuing for CPU terminals.

f) Incoming call restriction to CPU.

2.7.11 System Features. These are features common to the entire system. Some are included in the basic system; others require additional memory or hardware and are available as options at additional cost.

2.7.11.1 System Administration. Equipment is available to control and place into the system's memory, line assignments, and changes in station and system features. It is also used for system diagnostics. Specify the requirement for this equipment in all acquisitions.

2.7.11.2 System Facilities Management, Equipment is available for controlling off-base calling. These include automatic alternate routing, automatic route selection, facility restrictions, circuit assurance testing, and traffic usage. Specify the requirement for this equipment in all acquisitions.

2.7.11.3 Cost Administration. Provide for automatic identification of outward dialing, and least cost routing capability. If the activity provides services to tenants, or has cost center systems of budgeting, specify the requirement for station message detail recording equipment designed to provide the following data:

a) Extension call detail.

b) Organization costs by cost centers.

2.7.11.4 Options. A study should be made of the requirements of the activity for the following three options.

a) Electronic Directory. For telephone systems larger than 500 lines, provide an electronic directory. For smaller systems a study should be made. This feature maintains a directory listing containing name, telephone extension number, room number, building number, and department or organization. The electronic directory listing is updated each time a telephone is added, disconnected or changed. The electronic directory can be accessed by the telephone operator, security personnel or others via terminals. When required, data can be printed on a line printer or magnetic tape for producing a directory.

b) Electronic Mail. Electronic mail facilitates the storage and transmittal of documents, entered via a terminal, to individual or multiple addressee terminals. Documents may be edited and retransmitted as often as required.

c) Building Management. This can monitor, control, and report on security and fire conditions, and access to secure areas.

2.8 Consoles. Specify desk top cordless consoles, equipped with 16-button dialing capability, for processing AUTOVON precedence traffic. The number of consoles required is dependent on the mission of the activity, and the duties of the console attendant. A study should be made to determine the number of consoles required. Provide a minimum of two.

2.8.1 Distance. The PBX must not exceed 950 feet from the consoles, without range extenders.

2.8.2 Features. The consoles shall be equipped, as a minimum, with the following features:

a) Switched loop operation.

b) Line number - trunk group display.

c) Call extension.

d) Internal completion.

e) Outward completion.

f) Hold and release.

g) Timed reminder.

h) Held call return.

i) Conference calling - three to six parties.

j) Busy verification.

k) Busy override.

l) Trunk group busy lamp.

m) Busy-out switch.

n) Night transfer.

o) Call splitting.

p) Paging.

2.9 Main Distributing Frame. If a new main distributing frame is required, specify a modular frame designed for short jumpers or connecting cords. It shall be dead front design equipped with heat coils and employ fast response, less than 5 nanoseconds, avalanche diodes with gas tubes to improve clamping time.

2.9.1 Special Service Protection. Specify the installation of identification rings and binding post insulators on all terminations of special circuits.

2.9.2 Special Safeguard Measures. Arrange to identify those circuits that are specially sensitive or important. In addition to providing special service protection devices for these circuits, arrange to remove all unused multiple appearances.

2.10 Power. Specify power equipment sized for the ultimate (10 year) power requirement.

2.10.1 AC Power. Determine the voltage and phase for the primary power to be supplied by the activity. Specify AC power panel designed to meet NFPA No. 70.

2.10.2 DC Power. Specify the necessary DC power panel, equipped with disconnect switches, fuses (including alarm fuses), and voltage and current meters designed to NFPA No. 70 standards.

2.10.3 Rectifiers. Specify a minimum of two rectifiers and regulators, each capable of carrying the full office load. These charging equipments shall be full wave, self-regulating, constant voltage, and solid state. They shall be designed to operate on a load sharing basis.

They shall be capable of operating at increased voltage to provide equalizing charge to the batteries. Provide supplemental equipment to charge the end cells, if the voltage required to charge these cells (in addition to the equalizing voltage) will exceed the safe voltage of the connected telecommunication equipment.

2.10.4 Batteries. Provide sufficient battery capacity to supply the peak load of the connected equipment for 8 hours, during an AC power outage, fluctuation, or switchover. In very large installations equipped with permanently connected emergency generating equipment, this time can be reduced to 4 hours. Two sets of 24 lead calcium cell batteries are preferred, if the load is sufficient to justify the cost of two sets. Batteries should have a design life of 14 years, when maintained on full float operation between 2.17 and 2.20 volts per cell. Provide adequate end cells, with automatic switching depending on the voltage requirements of the connected load. Counter EMF cells are not acceptable. All cells shall be equipped with explosion control devices. Sealed, maintenance free, gelled electrolyte lead calcium batteries may be used.

2.10.5 Standby Alternators. Except in very small installations (200 lines or less), where portable engine-driven alternators are provided by the activity, provide a properly sized, permanently installed engine or turbine-driven alternator. For installations using portable equipment, provide easy access for connecting the wires and a two position switch; one labelled "Standby" and one labeled "Primary." For installations with permanently installed equipment, provide either automatic transfer switches **or** a manual transfer switch properly labeled. Select and install this equipment in a manner to minimize noise and vibration.

2.10.6 Overcurrent Protection. Devices shall be provided in accordance with UL 1459, Telephone Equipment. Compute the capacity of these devices considering maximum load on the switching machine and all auxiliary equipment in service.

2.11 Environmental Considerations. Provide adequate space, temperature, humidity control, out-of-tolerance temperature and humidity alarms, and other environmental considerations outlined below.

2.11.1 Space. Provide sufficient space for an orderly arrangement of cabinets, to include maintenance space as required by the vendor. Clear ceiling height shall be a minimum of 9 feet. A raised floor is not required. Floor strength for the switching cabinets and miscellaneous frames shall be 50 lbs/sq. ft. minimum, and for the power plant and batteries, 225 lbs/sq. ft. minimum. The main distribution frame should preferably be in the same room as the switching equipment.

2.11.2 Temperature. Provide sufficient air conditioning capacity to maintain the temperature in the equipment space between 41 and 85 degrees F (5 and 30 degrees C). The rate of change in temperature shall not exceed 9 degrees F (5 degrees C) in 30 minutes.

2.11.3 Humidity. The relative humidity must be controlled between 20 and 60 percent noncondensing.

2.11.4 Area Lighting;. Provide area lighting in the equipment and power plant room and at the main distribution frame, in accordance with MIL-HDBK-1190, Facility Planning and Design Guide, for computer rooms. Provide indirect or dimmable lighting in the attendant console room to minimize glare on the console display area.

2.11.5 Emergency Lighting. Provide emergency lighting in the attendant console, equipment, and power plant (including standby alternator if installed) rooms and at the main distribution frame. Provide quick acting automatic transfer from primary power to standby power, and time delayed transfer from standby power to primary power. Provide for automatic recharging of the batteries.

2.11.6 Grounding System. Provide a multipoint grounding system, the resistance of which shall not exceed 5 ohms, to which all elements of the switching, power, and main distributing frame are to be connected. See MIL-STD-188-124A, Groundinn. Bonding and Shielding.

2.11.7 Seismic Safety. Provide the necessary protection in accordance with NAVFAC P-355, Seismic Design for Buildings.

2.12 Transmission. Develop a trunking diagram, with transmission levels, return loss, and signal to noise ratio requirements.

2.12.1 Trunks. The traffic study referred to previously will provide data for off-base message trunk usage. The number of trunks must be adjusted to provide the required grade of service. Similar adjustments must be made to cover any increase in number of stations in service by time periods. Provide only enough trunk modules, by trunk group, for 2 years anticipated growth. If no traffic data are available, provide a total of off-base trunks equal to 6 percent of the number of lines on-base. These off-base trunks should be divided among the various trunk groups, based on the current configuration.

2.12.2 Signalling Compatibility. The trunk signalling equipment must be compatible with the following types of trunks, as required by the trunking diagram:

a) DSN/AUTOVON.

b) FTS.

c) Public exchange.

d) Other common carrier.

e) Tie trunks.

f) Foreign exchange.

g) Satellite.

h) Other.

2.12.3 Special Service. Provide the necessary electronic equipment for the type of special service circuits currently in use and anticipated in the near future. These may include the following types:

a) Emergency - crash alarm.

b) Fire alarm.

c) Intrusion alarm.

d) Ring down.

e) Telemetering.

2.12.4 Fiber Optics. Consider the use of fiber optic systems for signal and data transmission. For system design see Section 17.

2.13 Distribution Cables. The design for distribution cables takes two forms. For distribution within a building, or between closely spaced buildings, provide cable pairs directly from the main distribution frame to floor terminals or to building entrance terminals. For locations with widely spaced buildings, use the cross-connecting terminal system. This system uses trunk (primary) cables between the main distribution frame and a full-count, cross-connecting terminal to the building entrance terminals. Consider the requirements for other signalling and communication systems when sizing the cables. Also consider that some new types of combination telephone and data station equipment require 2 to 4 pairs per instrument. Provide sufficient pairs to permit a station per line ratio of one. Trunk cables should be sized to be about 65 percent full initially, with reinforcement scheduled at about 90 percent of the pairs in use or faulty. Distribution cables should be sized to be about 50 percent full to provide for flexibility.

See TIA/EIA Standard 568, Commercial Building Wiring Standard, for additional information.

2.14 Conner Conductor Cable Material. Four types of materials are used in cable manufacture. These are for conductors, insulation, shielding, and the sheath. See REA Bulletin 345 series.

2.14.1 Conductors. Use solid, annealed round wire of commercially pure copper. Use the minimum size conductor (not smaller than 26 AWG) to serve the analog stations within the 1500 ohm (including the station equipment) maximum resistance limit. If calculations indicate a requirement for 19 AWG conductors, consider using a smaller gauge conductor and range extender or a range extender with gain as appropriate. If the conductors will be used for both voice and data transmission, the maximum allowable resistance is reduced considerably. In this case, consider the use of larger conductors or the use of modems.

2.14.2 Insulation. Conductor insulation shall be polyethylene with a high molecular weight or polypropylene, color coded in accordance with REA standards TE & CM 635. Unless there are requirements for low mutual capacitance cables (0.066 microFarad/mile), use standard 0.083 microFarad/mile cable.

2.14.3 Filled Versus Air-Core. Unless there is currently an air pressure system in service large enough to provide dry air to the additional cables, specify filled cables for installation in underground conduit and for burying in the ground without conduit. Use air-core cables for aerial construction except for very humid locations which require filled cables.

2.14.4 Shield. Specify a continuous aluminum or copper shield completely enclosing the cable core and wrapper according to REA Bulletin 345-67.

2.14.5 Sheath. The material for the sheath shall be either:

a) High-density polyethylene.

b) Low-density, high-molecular weight, ethylene copolymer.

c) Low-density, high-molecular weight, polyethylene.

2.14.6 Mechanical Protection. Where underground rodents are known or suspected to exist or in rocky ground, require a protective shield in accordance with REA Bulletin 345-67.

2.14.7 Parameters. Specify the requirements for the following:

a) Maximum resistance unbalance between wires of a pair.

b) Maximum crosstalk coupling.

c) Minimum insulation resistance.

d) Minimum high voltage breakdown.

2.15 Fiber Optic Cable Material. There are two basic types of fiber being manufactured: single mode and multimode types. The selection of the type of fiber to use depends on the system distance. For systems design, see Section 17.

2.16 Construction. Cable in conduit or buried directly in the ground is the preferred type of construction unless the terrain is prohibiting.

2.16.1 Direct Burial. Normally, cable should be buried a minimum of 24 inches deep, or protected by a 3 inch concrete cover. Specially important cables may be buried 36 inches deep. If there is a good probability that additional cable pairs will be required in the future, provide 4-inch polyvinyl chloride conduit on top of the cable.

2.16.2 Conduit. There are a number of materials used in conduit systems. Depending on the in place costs or, unique requirements, specify one of the following:

a) Polyvinyl chloride, thick wall used without concrete encasement.

b) Polyvinyl chloride, thin wall used with total concrete encasement.

c) Fiber.

d) Monolithic concrete (by using inflated rubber tubes).

e) Vitrified clay tile.

f) Concrete.

g) Wrought iron (very expensive).

h) Multiple small conduit placed inside larger conduit for fiber optic cable.

2.16.3 Manholes. Provide manholes as required for distribution or for splicing long sections of cable. Maximum distance between manholes shall not exceed 1000 feet for straight sections. This distance must be reduced for curved duct runs depending on the number of curves and the radius of curvature. Manholes shall be of sufficient size to permit placing equipment such as T-l Carrier repeaters. Provide detailed specifications for the rim and cover, pulling-in irons, and rocking hardware. Provide 27-inch minimum diameter rim and cover.

2.16.4 Aerial. Normally, it is desirable to place the cable on jointly occupied poles with low voltage electric power conductors. Only in exceptional circumstances should telecommunication cable be placed on poles supporting power conductors carrying voltages higher than 13 kV. Follow REA specifications TE & CM 635 and 641 for cable heights, pole strength, guying, and clearances.

2.16.5 Air Pressure Systems. If there is an existing air pressure system in service, and if the new cables will be protected by it, update the system if necessary. The system should have an air manifold, a total consumption meter, and individual rate of flow meters serving each cable and air pipe. It should have a transducer alarm system, using a telemetering system or manual testing. Update the air pressure schematics.

2.16.6 Fiber Optic Cable. The procedure for placing fiber optics cable is somewhat similar to that used for placing copper conductor cable. For systems design see Section 17.

2.17 Terminals. There are a number of different types of terminals used in a telecommunication distribution network. See appropriate sections of REA Bulletin 345 series. The major ones include:

a) Cross-Connect terminals are used to permit connecting any pair in the trunk (primary) cable to any pair in the distribution (secondary) cables. Provide specifications for these terminals and for the concrete mounting pads.

b) Buried Cable Pedestals. If buried cable is used, provide specifications for the pedestal and supporting hardware. Require that the pairs not terminated be protected by a shield from the pairs available for service at that location.

c) Aerial. Provide specification for aerial terminals. Require that the pairs not planned for service at that location be protected.

d) Building. Provide full count protected terminals, or crossconnecting blocks, at the entrance to a building. Due to the susceptibility of electronic station equipment to damage by voltage spikes, require properly grounded, 5 nanosecond, avalanche diodes with gas tube protectors.

e) Floor. Provide floor terminals as required.

2.18 Service Wire. If aerial cable distribution is used, there will be some need for paired wire between the aerial terminal and the station protector. This wire should be 18 AWG copper-steel or bronze, protected, and insulated with black neoprene or polyvinyl chloride. Provide tube protectors at the station end, properly grounded. In humid atmosphere, or areas subject to salt in the air, provide corrosion resistant hardware. See REA Bulletin 345-36.

2.19 Station Wire and Cable. In areas other than in return air plenums, provide station wire consisting of 3 or 4 pair (as required) 22 AWG copper conductors, insulated and covered with a polyvinyl chloride jacket. For wire to be used in return air plenums, specify characteristic fluoropolymer resin or equal as listed by the Underwriters' Laboratories. See NEC 8OO-3d. For secure areas, and for circuits subject to high transmission levels, provide shielded wire properly grounded at both ends. See REA Bulletin 345-18. Where pair requirements justify the use of station cable, provide 22 AWG or 24 AWG depending on allowable accumulated resistance from switching equipment or key system. If cable will be in a return air plenum, require the same type of insulation and sheath material as identified above. See REA Bulletin 345-59.

2.20 Station Equipment. An office-by-office survey should be made to determine the type of station equipment which will be required. See FCC Rules and Regulations, Part 68, Connection of Terminal Equipment to the Telephone Network.

2.20.1 Telephone Instruments. A number of types of telephones can be connected to a modern digital PBX to provide many of the same features formerly available only with key systems.

2.20.2 Dialing. Provide pushbutton dialing instruments where their higher cost is justified. Stipulate that the frequencies used must conform to REA Bulletin 345-74. Use rotary dial where pushbutton dials cannot be justified.

2.20.3 Signalling. Provide instruments with loudness control of the ringer. Some areas can justify tone or chime ringers.

2.20.4 Key System. There are some office functions that can justify the use of multibutton electronic key systems for improved office efficiency. Provide the specification for the instruments.

2.20.5 Single Line Stations. There is a long-term objective of the Navy to move toward a single line per station. However, this objective does not prevent multiple instruments on one line, where usage is light or the use of a multibutton key system as discussed above is justified.

2.20.6 Combined Telephone and Data Sets. Where required, specify instruments that have the capability to provide voice service and data transmission simultaneously.

2.20.7 Modems. Provide the necessary modems designed for the required baud rate.

2.21 Test Equipment. Provide test equipment, if required, for the operation and maintenance of the system. These include:

a) Oscilloscopes.

b) Transmission measuring system.

c) Volt-amp-ohm meters.

d) Buried cable locating equipment.

e) Insulation megger.

f) Ground resistance megger.

g) Cable testing equipment.

2.22 Training. Provide for training Navy personnel based on their assigned responsibility. These may include:

a) Telecommunications users.

b) Technicians for maintenance and program changes.

c) System Administrator.

d) Technicians for installation and maintenance of station equipment.

e) Technicians for maintenance of the distribution cable network.

f) Clerks for use and maintenance of records and documentation.

2.23 Test Plan. Specify that the selected vendor prepare, subject to Government approval, a proposed test plan. These tests should include:

a) All lines frame-to-frame for polarity.

b) All trunks for transmission and signalling compatibility.

c) Access all trunks and lines through the new switch.

d) Verify that PBX features required are accessible and operational.

2.24 Commissioning Plan, Specify that the selected vendor prepare, subject to Government approval, a proposed commissioning (cutover) plan. If technically possible, it is desirable to place the new switching equipment in service by a "flash cut," and to make station rearrangements immediately afterwards. This will cause the least amount of confusion for the user, and will permit user training immediately preceding access to the new features.

2.25 Decommissioning. Arrange for the old switching equipment to be deactivated immediately after the new switching equipment is placed in service. However, the old switching equipment should remain in place for a short period of time, while the new equipment is carrying the normal business day traffic. After the new equipment has proven it can carry the traffic satisfactorily, arrange to remove the old equipment. This removal should be performed carefully, to avoid creation of dust, if installed in the same room as the new equipment. Arrange for necessary repairs to the building.

Section 3: HOSPITAL NURSE CALL SYSTEMS

3.1 Description. A nurse call system provides communications between nurses and patients, other nurses, and doctors.

3.1.1 Audiovisual. This system has two-way voice communication, audio and visual alerting, and visual status lamps. System features include monitoring patients from the central nursing station, monitoring groups of patients, two way communication with patient, alert tone and visual indication of patient station initiated call, and room monitor visual indicator. This equipment shall be used for nurse stations covering up to 60 non-critical patient stations. Auxiliary equipment is available to alert personnel at remote locations.

3.1.2 Automatic Audiovisual, In addition to the features of the audiovisual system, this system is, controlled by a micro-processor, has several patient priority levels, and electronically displays patient calls in order of priority and sequence of initiation. The control station can serve up to 160 patient stations in its own area, and up to 640 patient stations in other areas. This equipment shall be used for nurse stations monitoring critical patient stations and for hospitals with more than 60 patient stations.

3.1.3 Radio/TV Control. Patient stations are available with cord sets for activating the nurse call, controlling radio, TV, lights and other accessories.

3.1.4 Physiological Monitoring. Physiological monitoring connections can be used simultaneously with other patient features.

3.1.5 Code Blue System. An integral part of the Nurse Call system, this system includes a switch and lights to summon help, primarily for cardiac arrest.

3.2 Requirements. All systems include a nurse control station located at each central nurses staffing area, corridor lights, and patient stations. Systems may also be provided with auxiliary stations and equipment. Outlet boxes or back boxes required for mounting station equipment will be specified by the vendor selected to provide the nurse call system. The wiring is low voltage using various quantities of 22 and 18 gauge wires as required by the vendor selected. The nurse call system must be connected to the emergency power system. See DM-33.02, Naval Hospitals, DM-33.03, Medical Clinics and Dental Clinics, and NEC 517 Part C.

3.2.1 Nurse Control Stations. The type of central nurse desk will determine whether a free standing control station desk unit or a flush wall unit will be provided. The control and power cabinets shall be mounted in an equipment room, in the vicinity of the nurse control station. The quality and amplification must be sufficient to monitor the largest group of patient stations. Lamp or light-emitting diode indicators must be bright enough to be easily read and positioned to keep glare to a minimum.

3.2.2 Patient Stations. The patient station shall contain a speaker-microphone, call placement lamp, a privacy lamp, a call cancel button and a jack for the cordset. The station shall be flush mounted, adjacent to the bed, with the center 4 feet above the floor. When the cordset is removed from the station, a call shall automatically be placed to the nurse control station. A combined station with individual features for each bed, will be used in two-bed rooms. Provide a 6-foot cordset for each patient bed. Select the type of cord sets from the following:

a) Call button.

b) Geriatric call button.

c) Oxygen tent call button.

d) Pillow speaker: microphone with radio/TV control and call button.

e) Pillow speaker: microphone with radio/TV control, auxiliary equipment control, and call button.

f) Medical monitor cable.

3.2.3 Toilet Stations. This station shall be mounted adjacent to the toilet, with the center of the mounting box 3 feet above the floor.

3.2.4 Shower Stations. This station shall have a waterproof mounting, with the center of the mounting box 6.5 feet above the floor. The shower station shall have a 6-foot nylon pull cord.

3.2.5 Staff Stations. In examining rooms and recovery rooms, the station shall be mounted with the center of the mounting box 4 feet above the floor. In operating rooms, the station shall be mounted with the bottom of the station at least 5.5 feet above the floor. Elbow or foot switches shall be provided. Staff stations do not receive patient audio or visual signals.

3.2.6 Duty Stations. These stations shall be placed in utility rooms, medical preparation rooms, medical records rooms, formula rooms, delivery rooms, and nurse lounges. They shall be mounted with the center of the mounting box 4 feet above the floor. The duty stations shall alert the nursing staff, both audibly and visually, that a patient is requesting aid.

3.2.7 Corridor Lamps. These shall be mounted on the ceiling or wall above the door of each patient room. When all door lamps cannot be seen from a corridor, zone lamps must be installed.

3.2.8 Psychiatric Patient Stations. This patient room requires tamper proof equipment for patient and staff safety.

3.2.8.1 Patient Stations. This station shall be mounted 4 feet above the floor. If the room is also to be used as a standard patient room, a cordset receptacle equipped with a tamper proof cover must be provided. The receptacle shall be mounted adjacent to the patient station.

3.2.8.2 Emergency Switches. This switch shall only be operable when the door switch is activated. It shall be mounted 3.5 feet above the floor.

3.2.8.3 Door Switch and Lamps. These shall be mounted outside the room, on the strike side of the door, 3.5 feet above the floor. This key controlled switch shall activate the room emergency switch, light an entry indication at the nurse control station, and light the indicator lamp at the key switch.

3.2.9 Code Blue Stations. A switch operation will light an indicator lamp on the switch plate and activate the code blue indicator at the nurse call station and other staff locations, as specified by the facility. It shall be located in intensive care rooms, 3.5 feet above the floor.

3.2.10 Zone Lamps. Zone lamps are installed when all door lamps cannot be seen from a corridor. A zone lamp will be located in each corridor to alert the nursing staff that a nurse call has been placed in the zone indicated by the zone lamp.

Section 4: HOSPITAL DOCTOR PAGING SYSTEM

4.1 Description. This system passes messages to doctors. The quantity of data conveyed varies by system and vendor. The hospital telephone operator potentially or the telephone system may function as an intermediary.

4.1.1 Audio Paging. This system uses speakers to transmit voice or audible coded messages, It is recommended where the features of a radio paging system are not justified.

4.1.2 Radio Paging. This transmits coded or voice messages over a radio frequency channel. The paging system can be connected to the telephone system, allowing paging from staff telephones. The system can also be used as a doctor registration system. If outside commercial paging systems are available to the hospital, they should be considered as an alternative.

4.1.2.1 Tone Paging is accomplished by a beep signal. The user must then contact a central dispatcher for the message.

4.1.2.2 Vibration. Paging is accomplished by a vibrator. The user must then contact a central dispatcher for the message. This method shall be used where a discrete signal is required, or disturbance of others should be avoided.

4.1.2.3 Visual Display. These receivers contain light emitting diodes or liquid crystal display message indicators. The receivers are provided with either tone or vibration alerting.

4.1.2.4 Voice. These receivers are capable of receiving voice messages, and are provided with either tone or vibration alerting. The voice messages can only be heard on the called receiver.

4.2 Requirements. The paging system shall be operated from the telephone system, or from one or more control locations as designated by the facility. See DM-33 Series. When more than one paging origination location is required, the system must be capable of indicating the location requiring a reply. The hospital doctor paging system must be connected to the emergency power system. See NEC Part C.

4.2.1 Audio Paging. When audio paging is required, use the sound system described in Section 7 of this handbook.

4.2.2 Radio Paging. This system is easily expanded to 1000 receivers. A 25 percent spare capacity shall be provided initially. Where required for adequate coverage, additional transmitters will be provided. The system features must be provided to match the receiver features.

4.2.2.1 Control Unit. The system shall be controlled via the telephone system.

4.2.2.2 Receiver Battery Charging Racks. Receiver battery charging racks for recharging the receiver batteries will be provided, near the entrance used by the doctors, for the initial quantity of receivers. Contiguous space for mounting 25 percent more battery charging racks must be available. If doctor registration is required, the battery charging racks shall be equipped for this feature as described in Section 5 of this handbook.

4.2.2.3 Antennas. Antennas shall be provided and located as directed in MIL-HDBK-1012/l, Electronic Facilities Engineering.

Section 5: HOSPITAL DOCTOR REGISTRATION SYSTEMS

5.1 Description. A doctor registering system indicates whether the doctor is in attendance at the facility. Messages received before the doctor has arrived are transmitted by a recall feature, which indicates message(s) are waiting upon "in" activation.

5.1.1 Manual. The doctor registers "in" or "out" by manual switching at a name indicator. If a message is waiting a "message waiting" indication is activated by "in" registration. This system is economical when the staff is small. These systems can be found in existing medium to large hospitals which were constructed before the availability of an automatic system.

5.1.2 Automatic. The doctor activates an entry/exit register, by either dialing a code number or using a coded card. "In/out" status can be checked, by dialing the doctor's number at any inquiry station. Telephone operators use an operator's console to codify "message waiting" indications such as "call operator" and "call your office," The more expensive components are justified for use in medium to large installations, by savings in wiring costs, reduction in wall space, more efficient operation, and easy expansion.

5.1.3 Telephone. This system is called via any telephone in the hospital. Registering "in" or "out" is accomplished by means of the telephone, and recorded messages are received. Video displays are located at strategic locations. The display lists the doctors who are checked "in" and shows a flashing asterisk after the name when a message is waiting.

5.2 Requirements. Preferably, all control cabinets and power supplies should be located with other hospital communication control equipment. See DM-33 Series. Name indicators or entry/exit registers should be located at all doctors entrances, and must include message waiting features. The hospital doctor registration system must be connected to the emergency power system. See NEC Part C.

5.2.1 Inquiry Stations. On automatic systems, inquiry stations allow determination of "in/out" status, in offices needing such information. "In/out" actuation or initiation of any call messages cannot be made at these stations.

5.2.2 Video Displays. These shall be located adjacent to the telephone operators, in the doctors lounge, in intensive care, and other areas needing this information.

5.2.3 Administration Terminal. On automatic systems, the administration terminal shall be located adjacent to the telephone operator or at an administrative location as required by the facility.

Section 6: INTERCOMMUNICATION SYSTEMS

6.1 Description. An intercommunication system allows voice communication between two or more points, where distance or background sound makes normal conversation impossible and frequency of use makes telephone communication impractical. Stations may originate calls or may only be able to reply to calls; area monitoring is another feature. Materials and equipment shall be in accordance with NFGS-16760, Intercommunication Systems.

6.1.1 Master-to-speakers. This system utilizes one master station, and as many speaker stations as necessary. The master can talk to all other stations, collectively or individually. Speaker stations reply only to the master. This system establishes communication at low cost, with inherent low flexibility.

6.1.2 Master-to-Master. This system utilizes only master stations. Any station can talk to any other in the system, providing maximum flexibility at high cost.

6.1.3 Compound Systems. This system has some master stations that talk to all or a number of the other stations, and some speaker stations which cannot originate calls. This type of system is a compromise between flexibility and cost, and should be considered for interbuilding systems where many small interdepartmental master-to-speaker stations are necessary.

6.1.4 Power Line Transmission. These systems use low frequency carrier applied to the power line to transmit between stations. This feature allows easy and economical system installation. Connecting the stations into the AC electrical outlet is all that is required.

6.2 Requirements. The necessity for a master or a-speaker station at a specific location is usually determined by the using agency. When this information is not available at the time of design, only a raceway and outlet system will be provided.

6.2.1 Raceway Size. Where communication requirements are unknown, and only a raceway system is provided, 3/4-inch conduit should be installed.

6.2.2 Power Line Transmission. This system may be used when a temporary requirement exists and installing conduit or exposed wiring is impractical or unsightly.

6.2.3 Stations. Any stations which can be called by more than one station should display a visual indication which identifies the calling station. This will be in addition to an audible signal. The visual indicator must remain activated until the call has been answered. Where compound systems are provided, the project drawings shall contain a chart indicating the features and interconnection required for each station.

Section 7: SOUND SYSTEMS

7.1 Description. A sound system provides audible coverage of large spaces by amplifying the applied sound and by carrying the sound to remote locations. Microphone, tape player, radio, or tone inputs may be used. The systems are used for instruction, entertainment, paging and emergency announcements.

7.2 Coverage. A sound system may cover only one room, many rooms in a building, several buildings, and outside areas. Within each listening area, either a central or distributed type may be used.

7.2.1 Central Sound Systems. This system utilizes one or more speakers located near the microphone. Such a system supplements room acoustics efficiently without appearing to change location of the person talking. For large spaces, power requirements are great and echoes and reverberation effects can be troublesome.

7.2.2 Distributed Sound Systems. This system uses many low level speakers distributed throughout the areas covered. Large areas can thus be served effectively by proper choice of speaker locations, at the expense of directional realism.

7.2.3 Zoned Sound Systems. Sound systems covering many listening areas shall be zoned. This permits programming and announcements to be directed to the appropriate zone(s), without distributing to the remaining zones.

7.3 Components. These include: an input source such as microphone(s), program equipment, or tone generating equipment; sound reinforcing devices such as amplifiers and mixers; the transmission medium such as cable and twisted pair wire; output devices such as speakers and horns; and control devices such as monitors, volume controls, input selectors, and zone selectors. Provide a dedicated cable system independent from other telecommunications services.

7.3.1 Microphones. Microphones should be selected to suit the usage anticipated. This might be paging, lecturing, stage performance, or audience participation. In selecting microphones, consider the following:

7.3.1.1 Impedance. Low impedance, high quality microphones should always be required. They provide superior sound reproduction. Furthermore, they are necessary where a built-in preamplifier is not practical and long cable runs occur between microphones and associated equipment.

7.3.1.2 Directional Patterns. Use an omnidirectional pattern when a person speaking is no more than 6 inches from the microphone. Otherwise feedback can be a problem. Use cardioid or figure eight patterns to reduce feedback when the speaking distance is greater than 6 inches or when group conversations are necessary.

7.3.1.3 Location. Microphones are usually attached to floor or table stands. If mobility is necessary, microphones may be worn around the neck or attached to clothing.

7.3.1.4 Windscreens. Windscreens shall be used when a microphone is used outdoors during adverse weather conditions.

7.3.2 Amplifiers. Various types of amplifiers are available and should be located to provide convenient control.

7.3.2.1 Preamplifiers. Use preamplifiers to match the microphone impedance and sound level to the power amplifier input requirements. Most microphones contain built-in preamplifiers. When external preamplifiers are required, they shall have volume and tone controls and should be located as close to the microphone as possible.

7.3.2.2 Mixers. Use a mixer amplifier for systems with multiple microphone and other input sources. Mixers shall include individual level controls for each input, and master gain and tone controls.

7.3.2.3 Power Amplifiers. Use a power amplifier for each program distributed simultaneously. Provide additional power amplifiers as required for adequate sound level at remote locations. The necessary capacity of any amplifier is determined by the maximum load due to output devices on any channel at any particular time. The output impedance of power amplifiers must match the characteristics of the sound reproducing devices.

7.3.2.4 Compressor-Limiter Amplifiers. Use the compressor-limiter to provide automatic compensation for the movement of speakers, either closer to or further away from the microphone.

7.3.3 Sound Reproducers. The number and placement of sound reproducers and the capacity for power handling must be carefully determined. This determination will be based on essential coverage, frequency response, and directional pattern. Directional characteristics vary widely depending on the design. Care must be taken to achieve the desired directional patterns over the desired frequency ranges.

7.3.3.1 Types. The two basic types of sound reproducers are the cone and horn.

a) Cone. The signal cone type is suitable for low or medium power levels such as for voice paging in small areas and for background music. The coaxial type consists of a dual or triple cone with a crossover network. This permits a wider range of frequency response than a single cone unit.

b) Horn. The multicellular or sectorial horn type of speaker consists of a driver coupled to a flared horn. It is used primarily for systems which handle speech where high power handling capacity is required. Directional coverage is controlled by horn design. The horn is also used as a high frequency unit in wide frequency range speakers where high power levels are needed. A speaker with a reentrant horn is used for industrial and outdoor applications where quality is secondary, such as in voice paging.

c) Combination. A wide frequency range speaker cluster has a low frequency cone and a horn speaker in a bass reflex or similar enclosure. The unit is provided with a crossover network to achieve a wide range of frequency responses and a high power level. The crossover network must be designed for the full power handling capacity of the cluster. These are used for high quality installations of a central system.

7.3.3.2 Enclosures. Cone or coaxial speakers require enclosures to suppress radiations from the back, and to increase low frequency response. The volume of the enclosure must be large enough so as not to reduce response at low frequencies.

a) Columnar enclosures have several speakers arranged in a vertical array. They improve intelligibility in reverberant and noisy locations, and minimize feedback.

b) Bass Reflex Enclosures. Bass reflex enclosures are used to improve low frequency response of wide frequency range speaker clusters. They are also used for coaxial speakers.

7.3.3.3 Mountings. There are ceiling and wall mounted types.

a) Flush mounted ceiling reproducers are used for distributed systems.

b) Wall mounted reproducers, either flush or surface mounted, are positioned to provide either central or distributed coverage.

7.3.4 Program Sources. Select components from the following to provide the required system.

7.3.4.1 Compact Disc Player

a) Single or multiple compact disc (CD) player.

7.3.4.2 Tape Recorders/Players

a) Multi-speed tape decks arranged to provide input to and record from the system.

b) Cassette type equipment arranged to provide input to and record from the system.

7.3.4.3 Radio Tuners. Provide amplitude modulation (AM) and frequency modulation (FM) tuners. Install additional tuners when different channels are connected to different radio stations at the same time.

7.3.4.4 Paging Systems. Provide for microphone or telephone system paging access. Provide for zone paging.

7.3.4.5 Tone Generators. Provide the types of tone generators required for paging and disaster alerting.

7.3.5 Controls. All systems require various controls. A complex system shall be equipped with a control console.

7.3.5.1 Monitor. Provide audible and visual monitoring. A switch shall be provided to connect the monitors to each channel in multichannel systems.

7.3.5.2 Simple Systems. Provide input controls on the preamplifiers for volume and tone. When a mixer is used, provide a volume control per input and a common volume and tone control.

7.3.5.3 Complex Systems. Provide a console, or rack mounted control devices, to control the following:

a) Each input channel volume.

b) Each channel and tone.

c) Connection of each channel to each zone, or any combination of zones.

7.3.5.4 Remote Volume Controls. Volume controls shall be provided at each remote room. When required, they may be user adjustable.

7.3.5.5 Automatic Noise Activated Volume Controls. Use these devices where sudden ambient noise changes occur, for example when a airplane flies overhead.

7.3.5.6 Failure Detectors. These monitor power amplifier operation. They provide audible and visual indication of failure, and will automatically transfer to a stand-by amplifier. Use where reliable communication is critical.

7.4 Cabling. All cable should be installed in conduit. Speaker wiring can be in l/2 inch conduit. All other conduit should not be less than 3/4 inch in size. Microphone, program source, mixer, telephone paging cables, and cable to sound reproducers shall be coaxial or shielded, twisted pair cable.

Section 8: CABLE TELEVISION SYSTEMS

8.1 Description. These systems include a family of systems with similar criteria. They include community antenna television (CATV) systems, master antenna television (MATV) systems, and closed circuit television (CCTV) systems. This section provides design guidance for Navy ownership of a community antenna television system. Other sections of this handbook provide specific guidance for designing the other three types of systems.

8.2 Source of Signal. The source of signals to be distributed by CATV systems may be direct off-the-air, satellite earth stations, terrestrial microwave, and those generated by an on-site studio. Factors to be considered for each type are discussed.

8.2.1 Direct Off-the-Air. Strength of the broadcast signals at the receiving antenna determines the antenna siting, type and number of antennas, and the requirement for preamplifiers or attenuators.

8.2.1.1 Siting. Due to the nature of broadcast signal propagation, provide the highest practical, safe, tower location.

8.2.1.2 Antennas. If the desired signals are arriving at the receiving antenna from one direction, and are of sufficient strength, one broadband VHF antenna and one broadband UHF antenna will be satisfactory. If the desired signals are arriving from multiple directions but each have sufficient strength, multiple Yagi antennas, each turned to the desired frequency may provide sufficient signal voltage to the headend receivers.

8.2.1.3 Preamplifiers or Attenuators. Weak signals from the receiving antennas may be strengthened by using a low noise preamplifier in the feed line to the receivers. If one signal is very strong compared to other signals, which could result in cross-modulation, provide an attenuator (filter) tuned to that frequency.

8.2.2 Satellite Earth Station. Signals from earth stations are subject to transmission loss between the earth station and the community antenna television system receiver. Provide amplification as required to deliver the required signal strength.

8.2.3 Terrestrial Microwave. Signals received from a microwave radio terminal may also be subject to transmission loss. Provide amplification as required.

8.2.4 Studio. Programs may be originated by the activity on site and distributed by the CATV system. The cost of the studio and associated equipment is dependent on the type and quality of program material. Factors to be considered include:

8.2.4.1 Lighting. Good television quality is dependent on adequate lighting of optimum chromatic mix and adequate air conditioning to remove the resultant heat.

8.2.4.2 Cameras. Depending on the quality of the signal to be generated, including monochrome or color, provide the required number, type, and quality of cameras. Provide one spare camera.

8.2.4.3 Microphones. Provide the required number and quality of microphones. Provide one spare microphone.

8.2.4.4 Video Tape Deck. User requirements will determine the number of video decks provided.

8.2.4.5 Environment. The studio must be treated against acoustic and light reverberation.

8.2.4.6 Electronic Controls. Consideration must be given to the following:

a) Mixers are used to feed various sources of audio signals into one transmission line.

b) Faders are used to decrease the signal strength from one video source as the strength from a second source is increased.

c) Audio-video modulators are required to condition the signal for distribution over the CATV system network.

d) Amplifiers are required to increase the signal strength to a level required by the distribution network.

8.3 Headend Equipment. The electrical equipment required in the headend will depend on the quality and intensity of the received signals, and on the bandwidth of the signals to be distributed. Equipment that must be considered includes:

8.3.1 Filters. These are used to attenuate extraneous noise.

8.3.2 Converters or Video Processors. These are used to convert the frequency of a received signal, or a band of signals, to a different frequency to reduce the cost of the distribution network.

8.3.3 Pilot Carrier. This is used to regulate the strength of the distributed signals as incoming signals fade, temperatures change, and aging of equipment affects the signal intensity.

8.3.4 Passive Combiner Network. These are used to combine signals from the multiple antennas, into a single frequency band, for injection into the receiving amplifier.

8.3.5 Overvoltage Protection. Provide protection against power line surges (spikes) and overvoltages.

8.4 Distribution. Signals from the headend are distributed to the television receivers through the cable distribution network.

8.4.1 Trunk Cable. Provide low loss coaxial cable or fiber optics cable, depending on cost, and equipment interconnection requirements.

8.4.1.1 Equalizer Amplifiers. These are required to neutralize the transmission loss in the preceding cable section. Calculate the change in signal level, from one extreme of temperature to the other extreme, and provide automatic level and slope amplifiers as required.

8.4.1.2 Bridging Amplifiers. These are used for bridging distribution cable to the main trunk cable. A terminating bridging amplifier is used at the end of the trunk cable for impedance matching and local distribution.

8.4.2 Distribution Cable, Since distribution cables tend to be relatively short, a higher loss coaxial cable is feasible and more economical.

8.4.2.1 Trunk Amplifiers. Few amplifiers are used in cascade on distribution cable. Consequently, they do not have to meet the strict tolerance for level, slope, and distortion products as required for trunk amplifiers.

8.4.2.2 Distribution Line Tans. Taps may be single or multiple (up to 8), depending on the closeness of the users.

8.4.3 Subscriber Service Cable. A flexible, polyethlyne-foam insulated, copper-covered steel conductor cable, with a copper braided shield, is normally used for the service cable. In areas subject to a strong radiated signal from nearby TV broadcast stations, service cable with multiple shield (all properly grounded at both ends) are used to minimize ghosting.

8.4.3.1 Splitters/Couplers. These are used if the signal is to be supplied to more than one TV receiver on the premises.

8.4.3.2 Converters. Provide converters or signal processing equipment as required to convert the incoming signal to the desired channel in the TV carrier.

8.5 Design Schematic Drawings. Provide an RF signal level drawing and an AC power drawing, in schematic form, for the entire system.

8.5.1 RF Level Drawings. Calculate and post, to a schematic drawing of the entire system, the required signal level in dBmV at key points including the most distant TV receiver.

8.5.2 AC Power Drawings. The voltage drop in coaxial cable for the trunk and distribution network must be calculated. This will determine the locations of the AC power feed points along the route which must be posted to the AC power drawings.

8.5.2.1 Fusing. Specify the type and current carrying capacity for all fuses.

8.5.2.2 Groundings. Specify the type, location, and maximum permissible resistance of grounds.

8.5.3 Cable Shielding: and Grounds. Specify the method to be used in connecting the cable shield to the grounding medium. Specify the type of ground and the maximum permissible resistance.

8.5.4 Things to Consider

a) One-way or two-way distribution system.

b) Frequency spectrum to be distributed.

c) Number and direction of channels and frequency of each.

d) Required minimum and maximum signal level, in dBmV, at user TV input.

e) Maximum cross-modulation permitted.

f) Optimum automatic gain control required.

g) Minimum carrier to hum ratio required.

h) Minimum carrier to noise ratio required.

i) Linearity of signal required at user TV input.

j) Maximum radiated signal strength permitted at any location in the network.

8.6 Construction. The construction of CATV system cable networks is very similar to telecommunication cable networks, as described in Section 2 of this handbook, with some special precautions. Regardless of the type of construction, it is especially important that the cable shield be continuous through splices and equipment housings. This shield should be grounded at each end and at a maximum spacing of 1000 feet. The radius of bends must not be less than the minimum recommended by the manufacturer.

8.7 Proof of Performance. Tests shall be made, and the results compared to the technical requirements, after the system has been in full operation for 10 days. A record of these tests should be retained as a guide to future maintenance and adjustments.

8.8 Documentation. Provide for copies of all manuals required for operation, adjustment, and maintenance of the equipment installed.

8.9 Labeling. Require that all electronic equipment be permanently labeled showing component name and supplier's part number.

8.10 As-Built Drawings. Include a requirement for as-built drawings of the entire system. The distribution network should be drawn to a scale of not less than 1 inch equal to 200 feet. Drawings shall show the locations of all equipment, cross-referenced to the item number listed in the documentation.

Section 9: MASTER ANTENNA TELEVISION SYSTEMS

9.1 Description. A master antenna television system receives the signals from local television stations or satellite repeaters, amplifies the signals, and distributes them to using locations.

9.2 Requirements

9.2.1 Antenna. The type of antenna is determined by the frequencies covered and the strength of these signals. Several antennas may be needed to cover all required frequencies.

9.2.1.1 Location and Orientation. The exact location and orientation of antennas should be determined by a signal strength survey.

9.2.1.2 Lightning Protection. The requirements for lightning protection should be followed as provided in MIL-HDBK-1004/6, Lightning Protection. Where lightning protection devices must be installed, ensure that proper grounding is provided.

9.2.2 Amplification. Preamplifiers and amplifiers should be used as follows:

9.2.2.1 Preamplifiers. Preamplifiers should be used when incoming signals are too weak to be accepted by the amplifier.

9.2.2.2 Amplifiers. Amplifiers should be used for signal amplification, as required, to overcome distributing system losses and to provide suitable output. A broadband amplifier may be suitable if it can cover all incoming channels and maintain adequate signal level inputs to the distribution system. Otherwise, single channel amplifiers for each input channel may be necessary.

9.2.3 Distribution. The distribution system cable characteristics and installation instructions provided in NFGS-16782, Master Television Antenna System, shall be used.

Section 10: MASTER ANTENNA FREQUENCY MODULATION SYSTEMS

10.1 Distribution. This system receives the signals from local frequency modulation radio broadcasting stations, amplifies the signals, and distributes them to user locations. Frequency modulated systems should be incorporated with the master antenna television system. The cost is thus greatly reduced.

10.2 Requirements. Materials and equipment shall be in accordance with NFGS-16782.

10.2.1 Antenna. The type of antenna is determined by the frequencies covered and the strength of received signals.

10.2.1.1 Location and Orientation. The exact location and orientation of antennas shall be determined by a signal strength survey.

10.2.1.2 Lightning Protection. The criteria for lightning protection are provided in MIL-HDBK-1004/6. Where lightning protection devices must be installed, ensure that proper grounding is provided.

10.2.2 Amplifiers. Provide amplifiers in accordance with the requirements for master antenna television systems. See paragraph 9.2.2. When a master antenna television system is also provided, the master antenna frequency modulation system amplifiers shall couple into the television system distribution network.

10.2.3 Distribution, The cable characteristics and installation instructions provided in NFGS-16782 shall be used for the distribution system.

Section 11: CLOSED CIRCUIT TELEVISION SYSTEMS

11.1 Description. A closed-circuit system transmits video and, when desired, audio signals over cable circuits. Closed-circuit television systems are used for functions such as security surveillance, program transmission, training, and monitoring.

11.2 Applications. Representative applications listed below satisfy requirements based on the use of a single function.

Applications Requirements

Application	Requirements
Chemical laboratories	A
Environmental chambers	E
Furnace flames	A
Gate	A (each gate)
Jet engine testing	E
Loading platform	C (one camera every 100 feet)
Printed information	A (2:1 interlace)
Brogs	C
Psychiatric interview	D
Radioactive areas	A, B
Railroad cars	A, B
Room surveillance	C
Silent paging	D
Smoke control	A
Surgery	B, D
Training	A, B, C, D
Warehouse	A (depends on area to be covered)
Water gauges on boilers	A

A = Camera, monitor.
B = Remote control of camera.
C = Cameras (more than one), monitor, video switcher, console.
D = Camera and more than one monitor.
E = Rugged camera, monitor.

NOTES: 1. Provide emergency power for all applications where loss of system would be hazardous.

2. Video tape recording might be required on many of the applications.

When more than one function is required, the resulting system can make multiple use of monitors and tape recording by means of switches. When complex systems are required, control consoles shall be used. The minimum requirements for a closed-circuit television system are a camera with suitable lens, a transmission medium, and a receiving device known as a monitor. Closed-circuit television systems, including complex systems, can be assembled as required from the following components.

11.3 Cameras. A modern camera is a small unit containing solid state, integrated circuits, with the exception of the camera tube. The camera should be selected in accordance with the application to be served.

11.3.1 Environment. Cameras operate within an ambient temperature range of 14 degrees F (-10 degrees C) and 122 degrees F (50 degrees C), and with an ambient humidity less than 90 percent. For extreme temperatures, see paragraph 11.4.1 of this handbook.

11.3.2 Resolution. The picture detail is determined by the number of horizonal scan lines and the method of field interlace.

11.3.2.1 Scan Lines. The number of horizontal scan lines shall not be less than 525, as set by the National Television Standard Committee. When improved resolution is required, e.g., surgical observation, higher scan rates shall be provided.

11.3.2.2 Interlace. Interlace describes the condition by which the lines in the second of two successive fields in a picture tube are spaced between the lines in the first field. An interlace of two to one should be used when fine details are required, in multi-camera/multi-equipment systems, and whenever standard TV receivers are used. A random interlace camera should be used in all applications where detailed observation is not required or where multi-camera/multi-equipment systems will not be used.

11.3.3 Automatic Iris. This automatically varies the camera amplifier sensitivity to compensate for variations in light levels. Cameras are available with ranges up to four billion to one) A mechanical iris on the lens is not required.

11.3.4 Camera Tube. The selection of a camera tube is determined by the scene illumination available.

Typical Scene Illumination

Illumination	Footcandles
Clear Sunlight	3,200 to 10,750
Overcast Day	300 to 1,075
Sunrise/Sunset	50
Twilight	0.5
Full Moon	0.003 to 0.03
Starlight	0.00001 to 0.0003
Overcast Night	0.000002 to 0.00002

11.3.5 Monochrome/Color. Color television systems are used only where color need has been justified, i.e. for hospital surgery, industrial process monitoring, or broadcast service.

11.3.6 Lens Selection, Select the lens speed based on the amount of light required on the camera tube. See paragraph 11.3.4. Select the lens focal length to provide the desired view. Tables are available that give scene dimensions for different focal lengths, at a range of viewing distances. When a camera is required to view scenes requiring various focal lengths, a zoom lens should be used.

11.4 Camera Housings and Mountings

11.4.1 Housings. A wide variety of housings are available for both indoor and outdoor use. Indoor housing includes decorator styled models, and models for drop ceilings. Outdoor models include rugged weatherproof designs, with accessories such as heaters, defrosters, coolers, sun shields, washers, and wipers.

11.4.2 Mountings. These are available in a wide range from decorator styled units to heavy duty weatherproof models. They can automatically scan or be remotely controlled for pan and tilt.

11.5 Monitors. Monitors must have the same resolution and type of interlace as cameras. The monitors should be located for minimum light reflections on tube faces. Avoid vertical mountings. Circular polarized face plates should be used where ambient lighting is high. For distances between monitors and observers, see below. Multiple 17-inch monitors should be used wherever possible for a large group of observers. The table below provides the minimum monitor sizes.

No. of observers	Distance in feet (millimeters1	Monitor size in inches (millimeters)
1	5 (1525)	6 (150)
1	10 (3050)	8 (200)
2	15 (4575)	14 (350)
3	20 (6100)	17 (430)
4	30 (9100)	21 (530)
5	35 (107000)	24-27 (600-700)

11.6 Television Projectors. Television projection systems are used for large group observing with movie theater type lighting.

11.7 Video Tape Recorders. Time-lapse video tape recorders shall be used when security surveillance recording is required, and shall contain a date/time generator. See MIL-HDBK-1013/l, Physical Security of Fixed Land-Based Facilities. When used in a system with more than one camera and switches, the cameras shall use external synchronization which is controlled by the time lapse recorder. When critical scenes are connected to a scanner, alarm callup shall be used.

11.8 Video Switchers. These shall be used when more than three monitors are required at one observing location. When critical scenes are connected to a scanner, alarm callup shall be used.

11.9 Motion Detectors. These shall be used for security surveillance where there might be periods of time, in excess of 15 minutes, without any scene activity. See MIL-HDBK-1013/1. The motion detector shall activate an audio alarm, activate the alarm callup of switchers, and activate the time lapse video recorder alarm sequence.

11.10 Consoles. These shall be provided when the number of monitors at one location exceeds six. The console shall contain the monitors, the video recorders, associated visual and audio alarms, and all system controls.

11.11 Microprocessor Control. This unit shall be considered when more than six cameras are monitored from one location, or two or more cameras require tilt/pan adjustment to view four or more scenes.

11.12 Transmission Distribution. Cable distribution is used for most closed-circuit systems. When program material is distributed, the transmission can be sent over a community antenna television system network. See Section 8 of this handbook.

11.12.1 Cable Distribution. Telephone cable is often used as a part of the distribution system; however, coaxial cables provide higher quality pictures and are less susceptible to noise interference.

11.12.2 Radio Frequency Distribution. The use of radio frequency distribution should be limited to circumstances such as the following:

a) Where master antenna systems are available for picture distribution.

b) Where lower quality pictures are acceptable.

c) Where standard television receivers are used.

d) Where there are no security restrictions.

11.12.3 Microwave Distribution. A license must be obtained from the Federal Communication Commission to operate this system within the United States. Such distribution is not advised normally for use on naval installations. Its use may be considered where video must be transmitted long distances and telephone lines are not available. A line-of-sight path must exist between transmitting and receiving equipment. When lines of sight are not available, the signals must be relayed by reflectors. Two or more microwave links can be connected in series for long distances, that is for over 20 miles.

Section 12: CLOCK PROGRAMMING SYSTEMS

12.1 Clock System Description. A clock system controls all clocks within a building, or a number of buildings, so that they all indicate the same time. Clock systems are usually provided where accurate time is required for multiple clocks. These systems are recommended for use in academic environments where classroom clocks should be synchronized with tone signals. Master clocks are provided with battery back-up to maintain correct time during power outages. When power is returned, the master clock sets all clocks to the correct time. Clock systems can be incorporated into energy monitoring and control systems.

12.2 Program Control Description. A program control system uses a central timer to signal numerous remote devices. All devices on a circuit are signalled simultaneously. The central timer can have several circuits individually scheduled. Program control systems can be incorporated into a clock or energy monitoring and control system.

12.3 Wiring. Host systems can operate using both of the following wiring methods simultaneously.

12.3.1 Direct Wired. This system requires dedicated wiring to all secondary clocks and program controlled equipment.

12.3.2 Power Line Carrier. This system controls secondary clocks, and program equipment, by carrier currents transmitted over the building AC secondary distribution system. In a multi-building facility, the primary AC distribution system is used.

12.4 Requirements

12.4.1 Master Clocks. When power line synchronization is not adequate, crystal control can be used to maintain clocks within a 2-second variation per month.

12.4.1.1 Electromechanical. These clocks are not recommended because of greater maintenance requirements and the difficult procedure for setting the control devices.

12.4.1.2 Electronic. This type of master clock should be used because of reduced maintenance requirements, simple procedure for setting controls, and increased flexibility of control.

12.4.2 Secondary Clocks

12.4.2.1 Clock Size. Clock sizes are determined by maximum viewing distances and relation to architectural designs. Minimum recommended sizes are as follows:

Distance feet (mm)	Diameter inches (mm)
100 (30 000)	12 (300)
150 (45 000)	15 (375)
150 and over (45 000 and over)	18 (450)

Digital clock numbers shall be 2 inches high with a maximum viewing distance of 50 feet.

12.4.2.2 Analog. Twelve or twenty-four hour clocks, with style to match architecture, shall be provided as required by the facility.

a) Manual-Reset, Group-Correcting Type. These clocks have dual synchronous motors. The system can be the least expensive, but it has a high degree of inaccuracy. It is appropriate where group time indication is necessary, such as at academic facilities.

b) Automatic, Individual, Self-Correcting Type. This system isappropriate where accurate time control is required.

12.4.2.3 Digital. Twelve or twenty-four hour clocks can be provided as required by the facility, Some digital clocks are available for alternate use as an interval timer with local controls.

12.4.3 Program Control. Although a program machine with accessories constitutes a system, it can be incorporated within other systems. A tie-in with a clock system is the most common arrangement. A program machine should include a channel for each function plus 25 percent spare capacity. Standard equipment provides 6 or 12 time control channels. Select a wired or a nonwired type based on the same criteria as for clock systems.

12.4.4 Wiring. In the selection of a type of connection, flexibility and initial cost should be considered.

12.4.4.1 Wired. A wired system has little flexibility. It is economical for small installations but not for those involving large scattered areas.

12.4.4.2 Nonwired. A nonwired system allows great flexibility because controlled equipment may be connected to the most convenient unswitched electric power circuit. This system should be used where clock density exceeds one per 40 square feet.

a) Transmitters. Transmitters are required for nonwired systems (signal generators where appropriate) and shall be located in an equipment room. They should be connected as close as possible to the main incoming secondary or primary electric power supply. When program controlled devices are used, equip transmitter with a code frequency for each channel.

b) Clocks. They can be plugged into any unswitched electric outlet.

c) Programmed Control Devices. These require receiving equipment. One receiving unit shall be used to control as many devices as possible having the same program control requirements.

12.4.4.3 Combination of Wired and Nonwired. On large systems, when there are areas of concentrated requirements separated from each other as in a campus environment, the concentrated areas can be wired to a receiving unit controlled by a master clock transmitter.

12.4.4.4 Program Controlled Devices Power Source. These devices may be connected to any unswitched 120V electrical circuit. They may be directly wired or plugged into any unswitched electrical outlet. When operation of a device must continue during a power outage a suitable reserve power source must be supplied.

Section 13: WATCHMAN TOUR SYSTEMS

13.1 Description. A watchman tour system checks that a watch tour was made by means of the stations located along the route. The system provides a permanent record of the time the watchman checked in at each point. This system is required in all buildings with day or night watch service.

13.1.1 Manual. In this system, portable recording clocks are operated by key stations strategically located along the watch route. This system is not recommended.

13.1.2 Electrical. This system consists of tour stations wired to a central station. As each tour station is activated, an indication is received at the central station. A circuit checking feature shall be provided to indicate circuit faults.

13.1.3 Combined Electrical and Manual. Combination may be used when temporary tour stations are established, or an existing manual system is extended.

13.2 Requirements. An entire building or structure must be covered. Each complete route should not take more than 40 minutes to traverse. Station locations should be such that shortcuts by stairways, elevators, or bridges cannot be made. Individual stations should be mounted securely on walls, about 38 inches above finished floors. Tour systems shall be combined with remote control and monitoring systems when such systems are provided. See Section 16 of this handbook.

13.2.1 Watchman's Clock. Where electrical tour stations are provided, each watchman must be provided with a recording key.

13.2.2 Watchman's Key

13.2.3 Tour Stations. Select tour stations from the following:

13.2.3.1 Manual. Provide a surface or flush mounted container with hinged door and with the key attached by a tamper proof chain. Where appropriate, as in public areas, provide a locked container.

13.2.3.2 Temporary. When a temporary tour station is required with an electrical system, provide a stationary, recording, key-controlled watch clock, with a 7-day recording disk.

13.2.3.3 Electrical. Provide a key operated switch to establish an electrical indication of the tour station at the central station.

13.2.4 Central Stations. Electrical systems require a central station to receive and record the signal sent from each tour station. The recording device must automatically produce a permanent record of time and station number of each tour station signal. Provide appropriate optional features from the following list.

a) Signal Lamps. For each tour station, a signal lamp shall light at the central station after each tour station signal. These lamps shall be automatically reset after the route is complete.

b) Tour Alarm. This feature causes an audible and visual alarm when the tour stations are not operated within a programmed check-in time.

13.2.5 Tour System Communication. When the facility requires communication with the watchman, the use of planned or existing communication systems (pagers, intercom systems, two-way radio) at the facility should be considered. If these systems are inadequate, the tour system can be equipped with the following:

13.2.5.1 Recall Lights. These are used to indicate that the central station personnel wish to communicate with the watchman.

13.2.5.2 Tour Station Telephone. In locations where available telephones are more than 100 feet away from the tour station, provide a restricted telephone at the tour station.

Section 14: DISASTER ALARM SYSTEMS

14.1 Description. A disaster alarm system alerts personnel to the existence of natural or man-made disasters. Signals must be coordinated with local civil defense and disaster area authorities. Similar systems can be used for facility disaster alarms. However, when both are to be used, care must be taken to provide a distinct tone and signal for each system.

14.2 Requirements. Systems are composed of actuating devices, signal devices, power sources, and appropriate controls.

14.2.1 Actuating Devices. Signals are originated by remote control from the offices of civil authorities, or by local pushbuttons. Each coded channel requires a signal cancelling button with a pilot light. An electronic program control system can also be used to actuate signal devices. The number of channels, and their coding, must meet the requirements of civil defense and local area disaster authorities.

14.2.2 Signal Devices. Horns of a high audio power output shall be used as signal devices. Their locations, on structures and buildings, must provide signals loud enough to be heard over the entire area or activity.

14.2.3 Emergency Power. An emergency source of electric power must be provided. See MIL-HDBK-1004/4, Electrical Utilization Systems.

14.2.4 Controls. A control cabinet is required, which shall be equipped with control switches, supervisory lamps, coding devices, audible fault indicators, and test buttons.

14.2.5 Fault Detection. An automatic fault detecting feature shall be provided to monitor the signal devices and the emergency power source.

Section 15: CENTRAL DICTATION SYSTEMS

15.1 Description. A central dictation system allows a person to dictate, at any time, from any telephone or special dictation device. The dictation is recorded for the typist transcription. These are the following types of systems follow:

15.1.1 Telephone Connected System. The central recording equipment is connected to a PBX telephone system. This provides a person with the convenience of using any telephone for dictation. The user can record, play back, correct, or signal an attendant by dialing code numbers.

15.1.2 Dedicated System. Since the expense of these systems is great, their use should be limited to locations where a telephone connection is unavailable, or where security requirements justify an independent system. A dedicated system includes the recording equipment, dictating sets, and connecting wiring. The system size varies from a single dictation set and recorder to many dictating sets, with automatic selecting equipment providing connection to several recorders.

15.2 Requirements. Systems require central equipment and can include dictating sets, connecting wiring, and other equipment. See DM 33 Series.

15.2.1 Central Recording: Units. Central recording units record dictations for later play back by the typist. The following features are required:

15.2.1.1 On-Off Lights

15.2.1.2 Intercommunication Controls

15.2.1.3 Voice Operated Relay. A voice operated relay is required, so that a machine is activated only when the dictating person speaks. This eliminates pauses on the recording medium.

15.2.1.4 Lights and Audible Signals. Lights and audible signals indicate that a recording machine needs reloading, a recording machine is in use, and intercommunication with the dictating person is requested.

15.2.1.5 Audible Signal. An audible signal warns the person dictating that the machine is nearing the end of the recording medium. This signal shall allow the person dictating sufficient time to finish a sentence.

15.2.1.6 Automatic Operation. When a machine is set for automatic operation, without an operator present, it shall shut off when the recording medium is completely used. A signal shall remain (on) to alert an operator that the machine has material requiring transcription.

15.2.1.7 Security. Security features shall permit only the person dictating to play back during a recording period, and only authorized personnel to play back after termination of dictation.

15.2.2 Dictation Positions. Dictation positions shall be capable of performing the following actions, without recourse to the central recording unit operator:

a) Connection to an available recording unit.

b) Correction.

c) Quick listenback.

d) Full play back.

e) Continuance of recording.

f) Signal to operator.

g) Disconnect from recording unit.

15.2.3 Wiring. Requirements for acceptable wiring should be reviewed with manufacturers, when telephone system wiring is not used.

15.2.4 Other Considerations. In the design of a central dictation system, special requirements could be satisfied by one of the following means:

15.2.4.1 Combinations. A combination recorder and transcriber can be provided when only a limited amount of dictation is recorded. This combination should be used when requirements are limited to a small department, when it is for security, or when specialized dictation material requires transcription by one stenographer.

15.2.4.2 Individual Recorders. Individual recorders are for "heavy" dictating loads.

15.2.4.3 Portable Recorders. Portable recorders should be compatible with central system transcribers. They should be used where requirements call for the person dictating to be in the field, or at locations not accessible to the central system stations.

15.2.4.4 Off-Site Dictation Positions. The ability should be provided to dictate into the central system from locations off of the facility, when many persons will dictate for short periods and connection costs will not be excessive.

15.2.4.5 Twenty-Four-Hour Recorders. Twenty-four-hour tape recorders might be necessary, where continuous monitoring is required. An example of this is when a guard must log all vehicles passing his post. On-call features of the central system can allow the guard to dictate data directly to the central recording units.

Section 16: REMOTE CONTROL AND MONITORING SYSTEMS

16.1 Description. Remote control and monitoring systems provide equipment for the Duty Dispatchers at a Central Supervisory Control Station to monitor and control remote equipment. Distance to the remote equipment is not a limiting factor. Choose transmission equipment suitable for the distance and functions involved.

16.2 Purpose. Energy monitoring and control systems are being installed at military installations as the key to a successful energy conservation program. Such systems, in addition to saving energy, protect and limit damage to equipment, and allow malfunctions to be corrected with minimal service interruption. In addition, these systems operate equipment only when necessary, thus extending equipment life and cutting down on the number of operating personnel required. They also improve maintenance management, perform related functions such as fire protection, security, life safety, and other real time functions. See MIL-HDBK-1037/4, Brigs and Detention Facilities. Various levels of control are available as follows:

16.2.1 Basic Local Controls. These are equipment control systems supplied or recommended by the equipment manufacturer. These systems turn equipment on or off, depending on sensor activated messages.

16.2.2 Single Building Systems. A microcomputer is used to control the independent local controls of several pieces of equipment in one building. In the event of a failure of the microcomputer, the local controls shall control the equipment.

16.2.3 Limited Area Systems. These systems employ a microcomputer to control the independent local controls of several pieces of equipment or equipment in several buildings. In the event of failure of the microcomputer, the local controls exercise control of the equipment.

16.2.4 Basewide Distributed Processing: Control Systems. These systems employ a minicomputer which controls numerous limited area systems or single building systems or both. Mass storage of information is used to keep records and to support a sophisticated software system. In the event of minicomputer failure, the limited area systems shall control the equipment.

16.3 Requirements., A system shall be provided when life cycle costing or energy conserving guidelines indicate a payback in accordance with existing criteria.

Section 17: FIBER OPTIC SYSTEMS

17.1 Description. Fiber optic systems relate to signal or data transmission via light through fiber as opposed to current through electrical conductor. The fiber materials are made of transparent glass, plastic, or a combination of the two. The fiber optic systems are used in all areas of data and signal communications.

Optical fiber is a non-conductive dielectric material and its dielectric characteristics provide protection against electromagnetic interference, electromagnetic pulse, and radio-frequency interference. Fiber optic cables provide many advantages over electrical conductors. They are lighter in weight and smaller in size while providing wider bandwidth choice, lower losses, no induced noise, no electrical shock hazard, lower maintenance, comparable life expectancy of 10 to 20 years depending upon installed environment, and very high data transmission capacity.

Designers should keep in mind that fiber optics are a rapidly changing field and it is important to check what is available in the market today before proceeding with design.

17.2 Basic Fiber Optic System. A basic fiber optic transmission system consists of the following:

a) A transmitter converts an electrical signal to an optical signal and sends the optical signal into an optical fiber.

b) The optical signal transmits through the optical fiber.

c) A receiver accepts the optical signal and converts it into an output signal.

17.3 Components of a Fiber Optic System. A fiber optic system contains three major components: the light source, the light detector, and the transmission medium (optical fiber cable).

17.3.1 Light Source. There are two types: Injection Laser Diode (ILD) and Light Emitting Diode (LED). ILDs are generally used in digital systems. ILDs provide greater power output and a narrower spectral bandwidth of light than LEDs, enabling more power to be coupled into the optical fiber and providing greater transmission capacity or bandwidth. ILDs are not linear, which limits their capacity to transmit analog channels. LEDs become attractive when bandwidth requirements and the system length permit; they are lower in cost, operate over a wide temperature range, have a longer expected life, and offer greater long-term stability.

17.3.2 Light Detectors. There are two types: Avalanche Photodiode Detector (APD) and P-type, Intrinsic, N-type Diode (PIN). The light detector accepts a light signal from the optical fiber and converts it into an electrical signal (current). APDs improve receiver sensitivity by approximately 10 dB or more over PIN detectors, since they provide internal gain stabilization against temperature variations. Basically, APDs are better than the PIN diode for detection, providing higher sensitivity and larger responsivity than the PIN detectors; however, they require an auxiliary power supply and are more costly than PIN detectors.

17.3.3 Transmission Medium. The ratio of the speed in the material to the speed in free space defines the reflective index of the material. When light traveling in one medium encounters another material of a lower reflective index, the light is bent towards the material of the higher reflective index.

If the angle of incidence is increased sufficiently, the bent light will travel along the interface of the two materials. This angle is known as the critical angle. At an angle greater than the critical angle, the light will be totally reflected from the interface and follow the transmission path. This is how light signals are transmitted through an optical fiber.

An optical fiber transmission medium consists of a core, a cladding, and a protective coating. The core material has a higher index of refraction than the cladding material, and therefore light is transmitted by a series of reflections from wall to wall of an interface between a core, the inner cylinder and its cladding (the outer cylinder). The core material can be plastic or glass; glass provides lower attenuation and greater bandwidth performance than plastic. The cladding material can be plastic or glass; glass provides greater stability and compatibility than plastic.

The reflection angle is unique to each fiber type and determines the length of the path associated with each fiber type. The result is that each fiber type propagates at a characteristic axial velocity, so that dispersion limits the maximum rate at which information can be transmitted.

17.3.3.1 Fiber Types. There are two types: single mode and multimode fibers.

a) Single mode fibers are step index type. When light travels at certain reflective angle within a fiber it is called a step index fiber. Single mode fibers (wavelength: 1300 or 1550 nanometers) are used for long distance systems such as long distance telephone lines with a distance greater than 6 miles having signal regenerator spacing intervals of 18 to 25 miles.

b) Multimode fibers are available in step and graded index types and are generally used for short distance systems (wavelength: 850 or 1300 nanometers).

(1) Step Index Type: Step index fiber is used in short localized systems such as Local Area Networks (LANs), aircraft or shipboard applications with their bandwidth limited to 30 MHz/km.

(2) Graded Index Type: In graded index fibers light travels in a parabolic (curved) profile which provides bandwidths greater than 1 GHz. They are used for systems limited to distances less than 6 miles.

17.3.4 Parameters Affecting the Transmission Characteristics of Optical Fibers. The parameters are attenuation, pulse dispersion, numerical aperture, bandwidth, rise time, and fiber strength.

17.3.4.1 Attenuation. Attenuation is a measure of the light losses (signal losses) designated in decibels of optical power lost per kilometer (dB/km). The losses result from absorption due to impurities in the glass, and scattering due to density fluctuations in the glass. Attenuation is inversely proportional to temperature.

17.3.4.2 Pulse Dispersion. Pulse dispersion is also called pulse spreading or widening, is the measure of the spreading or widening of the light signal (pulse), and is designated in nanoseconds per kilometer (ns/km). There are two types of pulse dispersion: intermodal and intramodal. The intermodal dispersion results when light rays travel at different distances based on paths they are traveling in a fiber. The intramodal dispersion has three types: (1) material dispersion due to different index of refraction of the fiber; (2) waveguide dispersion due to bandwidth of the signal and the waveguide configuration; and (3) cross-product dispersion due to leakage of optical energy from one material to another. Consequently, pulse spreading is a function of the path length and it is given in nanoseconds per kilometer (ns/km). The bandwidth can be calculated from the pulse dispersion and is given in MHz/km.

17.3.4.3 Numerical Aperture. Numerical aperture (NA) is a measure of light collecting capability of a fiber and it is represented by the sine of the light acceptance angle (NA = 1.0 maximum). A large NA permits more light to enter the fiber. NA values are typically between 0.20 and 0.60.

17.3.4.4 Bandwidth. Bandwidth is a frequency range of a fiber's information transmission capacity.

17.3.4.5 Rise Time. Rise time identifies if selected parts will- operate at speed required.

17.3.4.6 Fiber Strength. Fiber strength is measured in terms of tensile strength of fiber.

17.4 Cable Structures. In general, the same type of sheathing used with copper-based systems can be used with glass-based systems. The systems may include aerial cables, submerged cables, rodent-resistant cables, and other types of cables. Cables designed to contain electrical conductors and optical fibers are also available and the electrical conductors are used for signaling applications or for carrying electrical power for signal regenerators.

17.4.1 Cable Specifications. Consider the following for specifying fiber optic cable:

a) Attenuation
b) Bandwidth
c) Operating temperature range
d) Tensile strength
e) Compression strength
f) Bending radius
g) Ice loading
h) Flexing (number of times and angle)
i) Numbers of fibers
Length and minimum length of continuous run
j) Specific shape requirement
l) Cable support requirement
m) Specific environmental requirement
n) Fiber dielectric composition and construction requirements
o) Overall cable construction requirement
p) Any requirement for non-magnetic or non-metallic cables.

17.4.2 Cable Types. There are five cable types: loose tube cable, tight tube cable, plenum cable, ribbon cable, and submarine cable.

17.4.2.1 Loose Tube Cable. Loose tube cable is designed such that it allows fiber movement within a tube that houses an optical fiber and provides protection against microbends (microcracks) on the fibers and temperature changes. The void areas inside the cable are filled with a filling compound such as a gel or powder, The loose tube cable can accommodate up to 144 fibers. It is commonly used in many applications including aerial installations with proper encasement and support but it is more difficult to splice than a tight tube cable.

17.4.2.2 Tight Tube Cable. Tight tube cables have a buffer coating on the optical fibers. The buffered fibers are tightly encased with a cable jacket resulting in more compact and more flexible design than a loose tube cable. The advantage of this cable type is greater protection against crushing and high impacts. For this reason, it is used for tactical military use where such protection is crucial. On the other hand, it is more susceptible to microbends or microcracks due to bending, thus, generally resulting to a higher attenuation than the loose tube type. Tight tube cable is not recommended for use in aerial or direct buried applications.

17.4.2.3 Plenum Cable. There are two types: tight and loose tube types. As the name suggest, it is designed for use in plenum or air handling spaces above suspended ceilings and must meet NEC fire resistance and smoke requirements.

17.4.2.4 Ribbon Cable. The ribbon cable has a ribbon (or ribbons) of linear arrays of 6 to 12 coated fibers inside a cable sheath. Ribbon cables are mainly used for telephone lines.

17.4.2.5 Submarine Cable. The submarine cable, a loose tube type, is specifically designed for use in underwater applications and it usually has a double armor construction. Due to maintenance problems associated with underwater operation, it is strongly recommended that each cable be installed with a spare cable for continuous operation in case one fails.

17.5 Fiber Optic Cable Operating Temperature Range. The cable operating temperature requirement should be based upon environment where the cables are to be installed. Cables are generally available in the operating range of -40 to 158 degrees Fahrenheit (-40 to 70 degrees Celsius) and they should be suitable for most installations. Where cables are subject to water immersion at temperatures below 32 degrees Fahrenheit (0 degree Celsius), use cables with a polyurethane filling compound in the buffer tubes. Where the fiber optic cables may be exposed to fire, specify the cables per IEEE-383 flame-retardance specification.

17.6 Impact of Nuclear Radiation to Fiber Optic Cables. Being dielectric material, fiber optic cable provides better protection against radiation than that of electrical conductors. However, in an area subjected to continuous high-intensity radiation the nuclear radiation causes increases in light absorption. This effect is called a darkening of the fiber core resulting in higher attenuation and may reduce the optical signal to an unacceptable level of use. The darkening is less severe at longer wavelengths. Consult manufacturer(s) for use of fiber optic cable in areas subject to high-intensity nuclear radiation.

17.7 Surge Protections. All communications equipment should be protected against power line surges per IEEE C62.41 and against surges induced on communication signal circuits. Protect fiber optic transmitters and receivers with surge protectors. Fuses shall not be used for surge protection.

17.8 Fiber Splices. Optical fibers can be spliced in two ways: by mechanical. splices or by fusion splices. There are various types of mechanical splicing methods available and losses (attenuation) vary from 0.1 dB to 0.5 dB. Fusion, spliced by melting the optical fibers together, provides significantly lower attenuation than that of mechanical splicing, but it is generally more expensive. Losses are typically less than 0.1 dB.

17.9 Optical Connectors. Splicing and terminating with appropriate connectors is an important part of the optical link. There are two types of system connectors; group connectors and individual connectors. The group connector losses in transmission are typically 3 to 5 dB. The individual connector losses in transmission are typically 0.5 dB. Individual connectors are more expensive.

17.10 Fiber Optic Cable Installation. Fiber optic cables are similar to conventional cables in terms of handling and installation procedures. The limiting tensile load varies among different types of cables from manufacturer to manufacturer. The cables should be able to withstand an installation tension up to 600 pounds or the level specified for the particular application; therefore, many conventional installation tools and procedures can be adopted to optical cable. A few essential differences must be recognized, however, to ensure a successful installation. Glass, although intrinsically strong material, is relatively brittle. It is important to monitor and control the cable pulling force during installation. Unlike copper conductors, which can stretch up to 20 percent before breaking, glass fiber can only be strained 1 to 2 percent before breaking. Fiber optic cables have a maximum allowable bending radius, generally no larger than 10 times the outside cable diameter with no load on the cable and no larger than 20 times of that under full rated tensile load.

Do not bury fiber optic cables directly underground. As a minimum for underground installation, fiber optic cables should be enclosed in a polyethylene or PVC conduit with inside diameter at least 4 times the outside cable diameter. Considerable attention should be given to determining the correct lengths of the cable to order and install. The objective should be to determine the cable segment lengths required for the installation without exceeding maximum recommended tensile load and to permit cable splicings and connections as required.

17.10.1 Duct and Tray Installations. Duct and tray installation is the most common and easiest method to install fiber optic cables. Although non-conductive properties of the fiber optic cables allow them to be placed with high-voltage cables in the same ducts without any special shielding requirement, it is not recommended due to personnel safety hazards during maintenance. As a minimum, provide a means of enclosed separation between them. Also, when fiber optic cables are to be installed in ducts, route the cables to avoid potential cutting edges, sharp bends, and heavy cable cross-overs.

17.10.2 Conduit Installations. Avoid excessive bending or friction on the cable in installing fiber optic cables. Consult manufacturer(s) for maximum allowable bending radius and maximum allowable pulling force for cables to be installed. Use proper fittings to avoid sharp bends or pressing against corners. Use pull boxes at an interval of 250 feet on straight runs to reduce pulling tension. Provide the pull box with an opening equal to at least 4 times the maximum allowable bending radius. Consider the use of inner duct for installing fiber optic cables.

17.11 Fiber Optic Cable Testing. Include specifications for testing and acceptance of fiber optic components, i.e. cables, splices, modems, and terminal equipment.

17.12 System Design. There are two types of systems, the analog and the digital system. For analog systems, the design goals are specified in terms of Signal-to-Noise Ratio, (SNR) bandwidth, and distortion level. For digital systems, the design goals are specified in terms of Bit Error Rate (BER) and bandwidth. For both systems, calculations that pertain to the overall SNR or BER performance must be performed.

17.12.1 System Considerations. For new systems, specify one complete system by one manufacturer. For a modification to or upgrade of an existing system, consider compatibility of a new system or components to be interfaced with by varying each system component requirement.

17.12.2 System Design Summary. To determine whether or not the system has adequate optical power to meet the design goal for SNR or BER, prepare a system design summary as follows:

SYSTEM DESIGN SUMMARY

1. Select 5 Vdc or 15 Vdc for power supply or check existing power system: ____________ Vdc

2. Temperature Range: ____________

3. System Distance: ____________ km

4. Select transmitter, light-source, detector, and receiver:
____

5. Signal Bandwidth (Refer to 17.12.3): ____________ MHZ/km

6. Signal-to-Noise Ratio (Analog System): ____________ dB
Bit Error Rate (Digital System): ____________ dB

7. Select cable and fiber type: ____________

8. Check Fiber Bandwidth (Fiber Bandwidth x Distance): ____________

9. Power Margin: ____________ dB
(Light Source Output Power minus Receiver Sensitivity)

10. System Attenuation:

a. Fiber Losses: ____________ dB

b. Connector Losses: ____________ dB

C. Splice Losses including future repairs: ____________ dB

d. Detector Coupling Losses (1 dB): ____________ dB

e. Time Degradation (3 dB): ____________ dB

f. Temperature Degradation (3 dB): ____________ dB

Total System Attenuation: ____________ dB

11. Check if Power Margin is greater than the Total System Attenuation. If power margin is greater, then the system is acceptable otherwise it is not acceptable. ____________

12. Receiver Power: ____________ mW ____________ dB

Note: Data for items 6, 8, 9, 10.a, 10.b, & 10.c can be obtained from manufacturer's data sheet.

17.12.3 System Bandwidth Calculation. Each fiber optic cable has its own fiber bandwidth limitation. Therefore, the bandwidth of the selected fiber optic cable must satisfy the signal bandwidth requirement. The calculation can be performed by first taking the square root of the sum of the squares of the individual module rise times:

EQUATION:

$$t_s = 1.1\sqrt{(t_{rTx})^2 + (t_{rf})^2 + (t_{rRx})^2} \qquad (1)$$

Where: t_s is the total system rise time
t_{rTx} is the light output rise time from the transmitter
t_{rf} is the rise time of the fiber
t_{rRx} is the receiver rise time

Note: 1.1 is a tolerance factor
Individual rise times can be obtained from manufacturer's data sheet.

The overall system bandwidth is calculated using the standard relation:

EQUATION:

$$BW_e = \frac{0.35}{t_s} \qquad (2)$$

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REFERENCES

NOTE: THE FOLLOWING REFERENCED DOCUMENTS FORM A PART OF THIS HANDBOOK TO THE EXTENT SPECIFIED HEREIN. USERS OF THIS HANDBOOK SHOULD REFER TO THE LATEST REVISIONS OF CITED DOCUMENTS UNLESS OTHERWISE DIRECTED.

FEDERAL/MILITARY SPECIFICATIONS, STANDARDS, BULLETINS, HANDBOOKS, AND NAVFAC GUIDE SPECIFICATIONS:

Unless otherwise indicated, copies are available from the Naval Publishing and Printing Service Office (NPPSO), Standardization Document Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

STANDARDS

MIL-STD-188-124A	Grounding, Bonding and Shielding

HANDBOOKS

MIL-HDBK-1012/1	Electronic Facilities Engineering
MIL-HDBK-1013/1	Design Guidelines for Physical Security of Fixed Land-Based Facilities
MIL-HDBK-1037/4	Brigs and Detention Facilities
MIL-HDBK-1190	Facility Planning and Design Guide

GUIDE SPECIFICATIONS

NFGS-16760	Intercommunication System
NFGS-16782	Master Television Antenna System

NAVY MANUALS. P-PUBLICATIONS. AND MAINTENANCE OPERATING MANUALS:

Available from Commanding Officer, Naval Publications and Forms Center, (NPFC), 5801 Tabor Avenue, Philadelphia, PA 19120-5099. To order these documents: Government agencies must use the Military Standard Requisitioning and Issue Procedure (MILSTRIP); the private sector must write to NPFC, ATTENTION: Cash Sales, Code 1051, 5901 Tabor Avenue, Philadelphia, PA 19120-5099.

DM-33.02	Naval Hospitals - Design and Construction Criteria
DM-33.03	Medical Clinics and Dental Clinics - Design and Construction Criteria
P-355	Seismic Design for Buildings

OTHER GOVERNMENT DOCUMENTS AND PUBLICATIONS:

FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Rules and Regulations	Connection of Terminal Equipment to the Telephone Network, Part 68.

(Unless otherwise indicated, copies are available from the Federal Communication Commission 1919 M St NW, Washington, DC 20554).

DEFENSE COMMUNICATION AGENCY (DCA)

DCAC 310-225-1	DSN Phase 1 User Service Guide
DCAC 310-V175-6	System Interface Criteria
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(Unless otherwise indicated copies are available from the Defense Communication Agency, Washington, DC 20305-2000 (ATTN: Code H316 for DCAC and Code B500 for DCEC)).

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NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70-84	National Electrical Code (NEC)

(Unless otherwise indicated copies are available from the National Fire Protection Association, Inc., Batterymarch Park, Quincy, MA 02269).

RURAL ELECTRIFICATION ADMINISTRATION

REA Bulletins	345 Series
REA Specifications TE & CM	
635	Air Cable Plant
641	Burial Plant

(Unless otherwise indicated copies are available from the Rural Electrification Administration, Telephone Engineering and Operations Division, Washington, DC 20250).

UNDERWRITERS' LABORATORIES, INC. (UL)

UL 1459	Telephone Equipment

(Unless otherwise indicated copies are available from the Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook IL 60062).

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